**If Life Hands You Lemons Make a Battery**

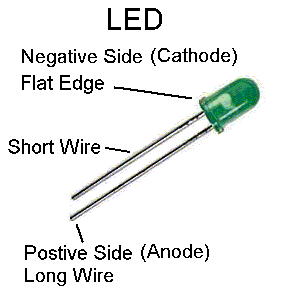
**Explanation**

A lemon battery generates electricity (a flow of electrons) due to chemical reactions occurring at electrodes inside the lemon. The outer coating of zinc on a galvanized nail is oxidized, and the nail becomes a negatively charged anode. The electrons that are released flow from the zinc through a wire to a copper wire, which channels the electrons to the positive hydrogen ions, H+ in the lemon’s acidic juice. The hydrogen ions are reduced to neutral hydrogen atoms, which pair to form hydrogen gas, H2. The copper wire piece becomes a positively charged cathode as the electrons are funneled away. Both reactions are shown below, along with the net reaction.

|  |  |  |
| --- | --- | --- |
| The galvanized nail, zinc electrode (anode) | Oxidation: | Zn → Zn2+ + 2e– |
| The copper wire, copper electrode (cathode) | Reduction: | 2H+ + 2e– → H2 |
|  | Net reaction: | Zn + 2H+ → Zn2+ + H2 |

One misconception that you may have is that the lemons themselves are the batteries producing the current. The lemons provide the liquid electrolyte that completes the circuit. The source of current (the electron flow) is the zinc atoms of the galvanized nail.

**Anatomy of an LED**



### Materials needed per student group

* Fresh lemon(s), lime, apple, etc.
* Copper Wires (1 per fruit)
* Galvanized Zinc Nails (1 per fruit)
* LED (anything under 4 volts)
* Alligator clips/wire
* Voltmeter or multimeter

### Procedure

**1-Cell battery (1 lemon)**

1. Applying some pressure, roll a lemon on a table to loosen the pulp inside.
2. With a knife, carefully make 2 small slits an inch or 2 apart in the lemon rind.
3. In 1 slit, insert the galvanized nail halfway into the lemon.
4. In the other, insert the copper wire piece halfway into the lemon.
5. Attach the alligator clip of 1 wire to the galvanized nail. This is the negative electrode.
6. Attach the alligator clip of another wire to the copper wire piece. This is the positive electrode.
7. Check the voltage by connecting the other ends of the wires to the positive and negative probes of a voltmeter or multimeter. (If the reading is negative, reverse the connections.) Record the voltage.

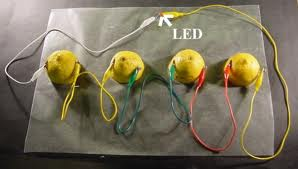
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ V (volts)

8. Generally, 1 lemon battery generates 0.9 volts. Try lighting the LED by

connecting the wires to the correct side. Remember to attach positive to

positive and vice versa.

**2-Cell battery (2 lemons connected in series)**

1. Repeat steps 1–4 above with a second lemon.
2. Attach the other end of the wire connected to the copper wire piece of lemon #1 to the nail of lemon #2. This positive-to-negative connection is called connecting in a series.
3. Attach a third wire to the copper wire piece of lemon #2. This wire is positive, while the wire from the nail of lemon #1 is negative.
4. Check the voltage of this 2-cell battery by connecting the other ends of the wires to the positive and negative probes of the voltmeter or multimeter. Record the voltage.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ V (volts)